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3,237,127

MAGNETIC CORE ORIENTING CIRCUIT

Filed June 17, 1964

2 Sheets-Sheet 1

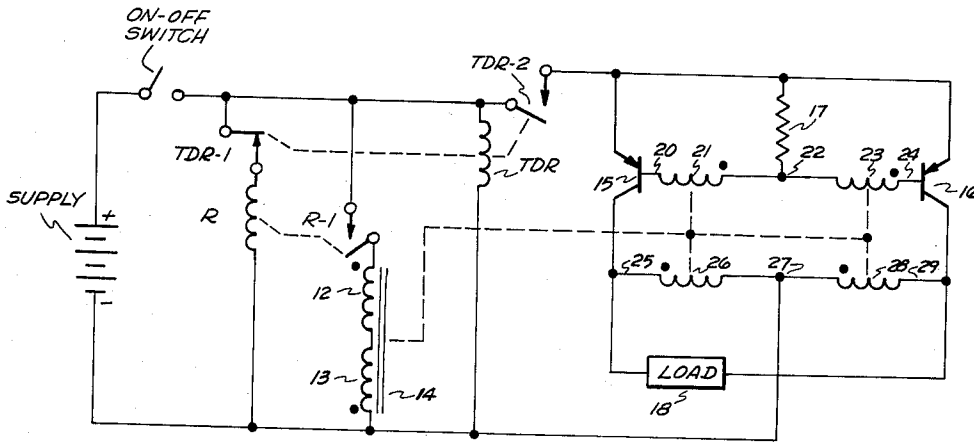


FIG. 1

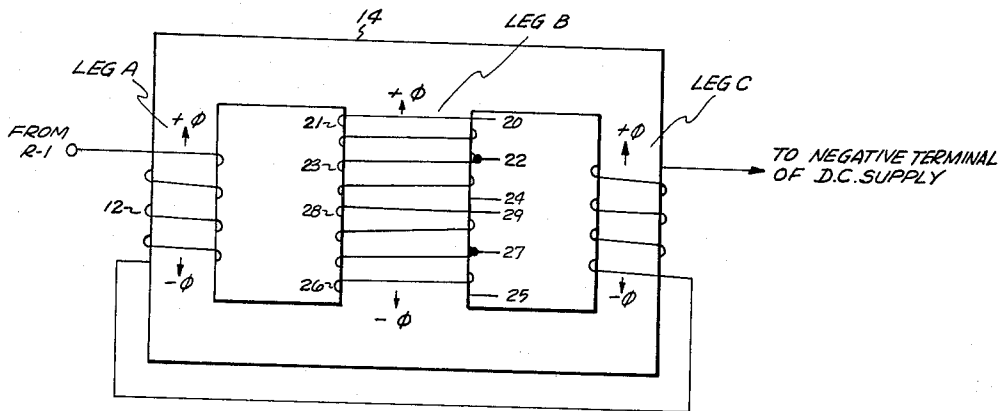


FIG. 2

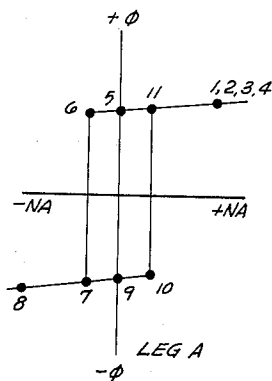


FIG. 3A

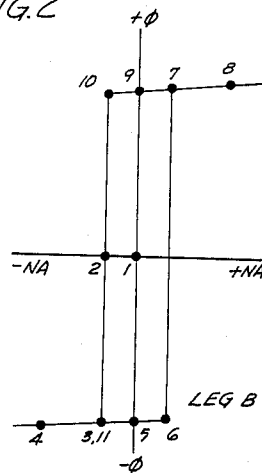


FIG. 3B

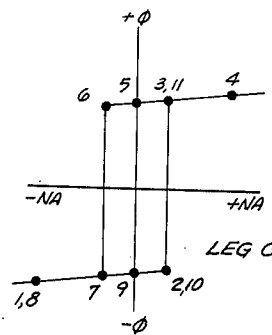


FIG. 3C

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2 Sheets-Sheet 2

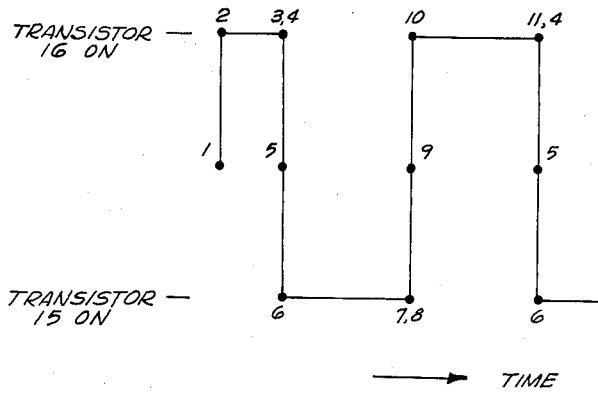


FIG. 4

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MAGNETIC CORE ORIENTING CIRCUIT

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2 Claims. (Cl. 331-113)

The invention relates to an orienting circuit for a magnetic core, and particularly to such an orienting circuit that can provide substantially and effectively zero residual flux or magnetism in a magnetic core.

Magnetic cores having substantially a square loop characteristic are used in many circuits such as oscillators, multivibrators, and timing generators. Such circuits utilize the volt-second characteristics of the magnetic core to achieve a desired operation or function. However, the desired operation of such circuits depends to a large extent on the magnetic core having a proper and preferably determinable magnetic flux condition at a particular time. For example, such a magnetic core with various windings is used in a known type of free-running multivibrator. When power is applied to such a multivibrator, the initial condition of the magnetic core determines the time at which the first oscillation or switching of the multivibrator occurs. This time can be important for many reasons, such as when the multivibrator is used to control an inverter circuit.

Accordingly, an object of the invention is to provide an improved circuit for orienting the flux of a square loop magnetic core to a determinable condition.

Another object of the invention is to provide an improved magnetic core and orienting circuit.

Another object of the invention is to provide a circuit that orients a portion of a magnetic core to a predetermined magnetic condition.

Another object of the invention is to provide a circuit for use with a magnetic core having a square loop, the circuit providing substantially and effectively zero residual flux or magnetism in a portion of the magnetic core.

Briefly, these and other objects are achieved by a magnetic core that has a first control path, a second control path, and an output path. A first winding is coupled to the first path, a second winding is coupled to the second path, and one or more utilization windings are coupled to the output path. The first and second windings are coupled in an input circuit to produce substantially equal and opposite magnetic fluxes in the output path in response to a common current through the input circuit. Means are coupled to the input circuit for causing this common current and for then stopping this common current. After this common current, the output magnetic path has effectively no residual magnetism or flux. Thus, the utilization windings can be utilized in any way desired with the output path in a known condition.

The invention is particularly pointed out in the claims. The invention may be better understood from the following description given in connection with the accompanying drawing, in which:

FIGURE 1 shows a circuit diagram of one embodiment of the magnetic core orienting circuit in accordance with the invention;

FIGURE 2 shows the construction and arrangement of a magnetic core and windings in accordance with the invention for use with the circuit of FIGURE 1;

FIGURES 3A, 3B, and 3C show hysteresis loops for explaining the operation of the magnetic core orienting circuit; and

FIGURE 4 shows a waveform illustrating the operation of the circuit of FIGURE 1 and the core of FIGURE 2.

FIGURE 1 shows a circuit diagram of a magnetic core orienting circuit in accordance with the invention. In

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FIGURE 1, it has been assumed that the magnetic core orienting circuit is utilized with a free-running multivibrator circuit that requires two center tapped utilization windings. The circuit of FIGURE 1 is provided with a direct current (D.C.) supply (indicated as a battery) which is applied through an on-off switch. This switch connects the D.C. supply to a series circuit comprising normally closed contacts TDR-1 and a relay winding R. The switch also connects the D.C. supply to an input circuit comprising normally open contacts R-1 and two control windings 12, 13. The contacts R-1 are closed in response to energization of the relay winding R. The control windings 12, 13 are connected relative to each other as indicated by the polarity dots, and are coupled to a magnetic core 14. The switch also connects the D.C. supply to a time delay relay winding TDR. After the time delay relay winding TDR has been energized for some time, the normally closed contacts TDR-1 are opened, and the normally open contacts TDR-2 are closed. The contacts TDR-2 connect the D.C. supply to the multivibrator circuit shown in the right-hand portion of FIGURE 1.

When the on-off switch is closed, the relay winding R and the time delay relay winding TDR are energized. The normally open contacts R-1 close relatively quickly and current is supplied through the control windings 12, 13 from the dotted end to the undotted end of the winding 12 and from the undotted end to the dotted end of the winding 13. Current flow through these windings 12, 13 causes the magnetic core 14 to have substantially and effectively zero or no residual magnetism or flux as will be explained. This current is permitted to flow through the windings 12, 13 until the time delay relay winding TDR operates its associated contacts TDR-1 and TDR-2. (The time delay relay winding TDR is designed to operate its contacts after the current has flowed for a sufficient time through the windings 12, 13.) When the contacts TDR-1 open, the relay winding R is deenergized. This permits the contacts R-1 to open and stop the current flow through the windings 12, 13. When the contacts TDR-2 close, power is supplied to the multivibrator circuit in the right-hand portion of FIGURE 1.

This multivibrator circuit shown to exemplify the invention is a known magnetically coupled multivibrator. The circuit comprises two PNP transistors 15, 16 having their emitters coupled to the contacts TDR-2. The collectors of the transistors 15, 16 are coupled to opposite ends of a load 18. This load may be an actual load or may be a winding of some kind which supplies output voltage to a further circuit. The circuit requires two center tapped utilization windings 21, 23, 26, 28 which are associated with the core 14 as indicated by the dashed lines. The windings 21, 23 are coupled in series between the bases of the transistors 15, 16 with the indicated polarity dots. The windings 26, 28 are coupled in series between the collector of the transistors 15, 16 with the indicated polarity dots. The center tap 22 of the windings 21, 23 is coupled through a base current limiting resistor 17 to the relay contacts TDR-2. The center tap 27 of the windings 26, 28 is coupled to the negative terminal of the D.C. supply.

The construction and arrangement of the magnetic core orienting circuit are shown in detail in FIGURE 2. The core 14 comprises three legs A, B, and C joined by upper and lower cross members. The legs A and C provide control magnetic paths, common portions of which form the leg B and an output magnetic path. Other cores, such as toroids, can also be used. The control winding 12 is connected to the relay contacts R-1 and is wound around the leg A. The control winding 13 is connected to winding 12, is wound around the leg C, and

is connected to the negative D.C. supply terminal. The utilization windings 21, 23, 26, 28 are wound around the leg B as shown. The core 14 may have a rectangular cross-section, and it is preferable that the cross-sectional area of the leg B be approximately equal to the sum of the cross-sectional areas of the legs A and C. As shown in FIGURE 2, the magnetic flux flowing or oriented upward in the legs is arbitrarily designated positive flux, and the magnetic flux flowing or oriented downward in the legs is arbitrarily designated negative flux. When the contacts R-1 are closed, current flows from the positive terminal of the D.C. supply through the control windings 12, 13 to the negative terminal of the D.C. supply. Under the right-hand rule, the control winding 12 produces positive flux in the leg A and the control winding 13 produces negative flux in the leg C. These fluxes cause the leg B to have effectively zero or no residual flux or magnetism. This can be explained in two ways. First, the positive flux from the leg A can be considered to flow downward through the leg B and the negative flux from the leg C can be considered to flow upward in the leg B, these fluxes in the leg B being equal and opposite. Or second, there is a single clockwise circulating flux in the leg A, the upper member of the core 14, the leg C, and the lower member of the core 14, so that no flux is present in the leg B. In either case, the leg B has effectively no residual magnetism or flux. The utilization windings coupled to the leg B can be provided with the initial condition of no flux. This initial condition is brought about by first energizing the control windings 12, 13.

The windings coupled to the output leg B are, as an example, utilized in the multivibrator circuit shown in the right-hand portion of FIGURE 1. With the output leg B in its initial condition of zero or no residual flux, when the contacts TDR-2 close, conditions in the multivibrator are in equilibrium. However, there will be greater leakage in one of the two transistors 15, 16. Assume that the transistor 16 has the greater leakage. Current flows down through the resistor 17, from the center tap 22 through the winding 23 to the end 24, through the base-collector path of the transistor 16, from the end 29 through winding 28 to the junction 27, and back to the negative terminal of the D.C. supply. The windings 23, 28 are coupled in regenerative fashion (as indicated by the dots) so that the transistor 16 becomes fully turned on. The output leg B becomes saturated, after which a small amount of reverse flux is introduced into the leg B. This reverse flux causes the multivibrator circuit to reverse its condition with the windings 21, 26 providing a regenerative effect such that the transistor 16 is turned off and the transistor 15 is turned on. As the transistors 15, 16 switch in the fashion just described, they provide alternate flows of current through the load 18. This current can be utilized in any desired fashion.

The operation of the magnetic core orienting circuit can be better understood with reference to FIGURES 3A, 3B, and 3C which are hysteresis loops of the legs A, B, and C respectively, and with reference to the waveform in FIGURE 4. FIGURE 4 represents the switching of the multivibrator circuit between the conducting conditions of the transistors 15, 16. In FIGURES 3A, 3B, 3C, and 4, corresponding points in time are indicated by the numerals 1 through 11 respectively. The hysteresis loops of FIGURES 3A, 3B, and 3C are plotted to approximately the same scale so that the flux changes in the output leg B are twice as great as the flux changes in the control legs A and C. After current has flowed in the control windings 12, 13, the control leg A is saturated with positive flux as indicated by the point 1 in FIGURE 3A, and the control leg C is saturated with negative flux as indicated by the point 1 in FIGURE 3C. The output leg B has zero flux as indicated by the point 1 in FIGURE 3B. Assume that the transistor 16 has greater leakage. Current flows through the center tap 22 through

the winding 23 to the point 24. Under the right-hand rule, the output leg B receives negative flux. This negative flux flows downward through the output leg B and upward through the control legs A and C. This has no effect on the leg A, since the leg A is already saturated with positive flux. However, the leg C begins to change or reverse its flux condition as illustrated in FIGURE 3C. This flux change follows the hysteresis loop from point 1 along points 2 and 3 to positive saturation at point 4. The leg B changes its flux condition in a corresponding manner from point 1 along points 2 and 3 to negative saturation at point 4 as shown in FIGURE 3B. The transistor 16 is turned fully on at point 2 and remains on through point 4. At the point 4, all legs are saturated, and the flux in the output leg B falls back toward point 5 on its hysteresis loop. This causes a reversal of conditions as shown by the points 5, 6, 7, and reaching a point 8, at which the leg B is saturated in the positive direction. The legs A and C make corresponding changes as shown by the points 5, 6, 7, and reaching a point 8 at which the legs A and C are saturated in the negative direction. The transistor 15 is turned fully on at point 6 and remains on through point 8. At point 8, the flux in the leg B again reverses itself so that the legs change their flux conditions as indicated by point 8, through points 9, 10, and 11, and become saturated in an opposite sense as indicated by the point 4.

FIGURE 4 shows the conducting states of the transistors 15, 16 at the various times relative to the points on the hysteresis loops of FIGURES 3A, 3B, and 3C. As shown in FIGURE 4, the initially conducting transistor 16 is on for the first time for a period of time that is one-half the subsequent conduction periods. In other words, the period of time from point 2 to point 4 is one-half the period of time from point 6 to point 8 or from point 10 to point 4. This is because the initial condition required that the output leg B change from a zero flux condition to a saturated condition. But subsequently, the leg B had to change from saturation in one direction to saturation in the opposite direction. Thus, with a constant D.C. supply voltage, the requisite time is twice as great for the subsequent flux changes as for the initial flux change. Expressed in another way, the volt-second product required for the leg B to go from saturation in one direction to saturation in the opposite direction is twice the volt-second product required for the leg B to go from a zero flux condition to saturation in one direction or the other. The initial zero flux condition is very desirable in circuits such as the multivibrator shown in FIGURE 1. With an initial zero flux condition, the multivibrator initially switches in a given time, and subsequently switches in twice that given time. Such reliable operation is very desirable in designing circuits which are controlled or operated by the multivibrator. For example, where the multivibrator is used to switch an inverter transformer, the time of switching can be accurately predetermined, and the inverter transformer can be designed on the basis of this predetermined time. It is not necessary that the transformer be designed with more iron, with its additional weight, size, and expense, to take care of a condition where the time of switching may be excessive.

While only one embodiment of the invention has been shown and described in detail, other embodiments can be provided. For example, other core structures can be used and still provide a control path or leg which initially has effectively zero magnetic flux. Such a core structure could comprise two toroids which have separate control paths and a common output path. Also, the circuit can be utilized with magnetic cores having various shapes of hysteresis loops. And finally, the orienting circuit can be used in a number of applications. Therefore, while the invention has been described with reference to a particular embodiment, it is to be understood that modifica-

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tions may be made without departing from the spirit of the invention or from the scope of the claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An orienting circuit comprising: a magnetic core structure having a first control path, a second control path, and an output path; first magnetizing means coupled to said first path; second magnetizing means coupled to said second path; means coupling said first and second means in an input circuit for respectively producing substantially equal and opposite fluxes in said output path in response to a common current flowing through said input circuit; utilization means coupled to said output path; said utilization means requiring zero flux in said output path prior to its being started to prevent its faulty operation; a source of potential for providing said common current flow when connected to said input circuit; and switching means operative to a first condition for connecting said source of potential to said input circuit to set said output path in a zero flux condition; said utilization means being inoperative when said switching means is in said first condition; said switching means being operative from said first to a second condition after the passage of an interval of time for opening said input circuit and permitting said utilization means to start operating whereby said utilization means starts operating with a zero flux condition in said output path.

2. An orienting circuit comprising: a magnetic core having a first control magnetic path and a second control magnetic path, respective portions of said first and sec-

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ond paths forming an output magnetic path; a first winding coupled to said first path; a second winding coupled to said second path; means coupling said first and second windings in an input circuit for respectively producing substantially equal and opposite magnetic flux conditions in said output magnetic path in response to a common current flowing through said input circuit; utilization means coupled to said output magnetic path; said utilization means requiring zero flux in said output magnetic path prior to its being started to prevent its faulty operation; a source of potential for energizing said input circuit; and switching means operative to a first condition for connecting said source of potential to energize said input circuit for a period of time; said utilization means being inoperative when said switching means is in said first condition; said switching means being operative from said first to a second condition after the passage of said period of time for deenergizing said input circuit and starting said utilization means whereby the utilization means always starts operating with a zero flux condition in said output path.

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JOHN KOMINSKI, *Examiner.*